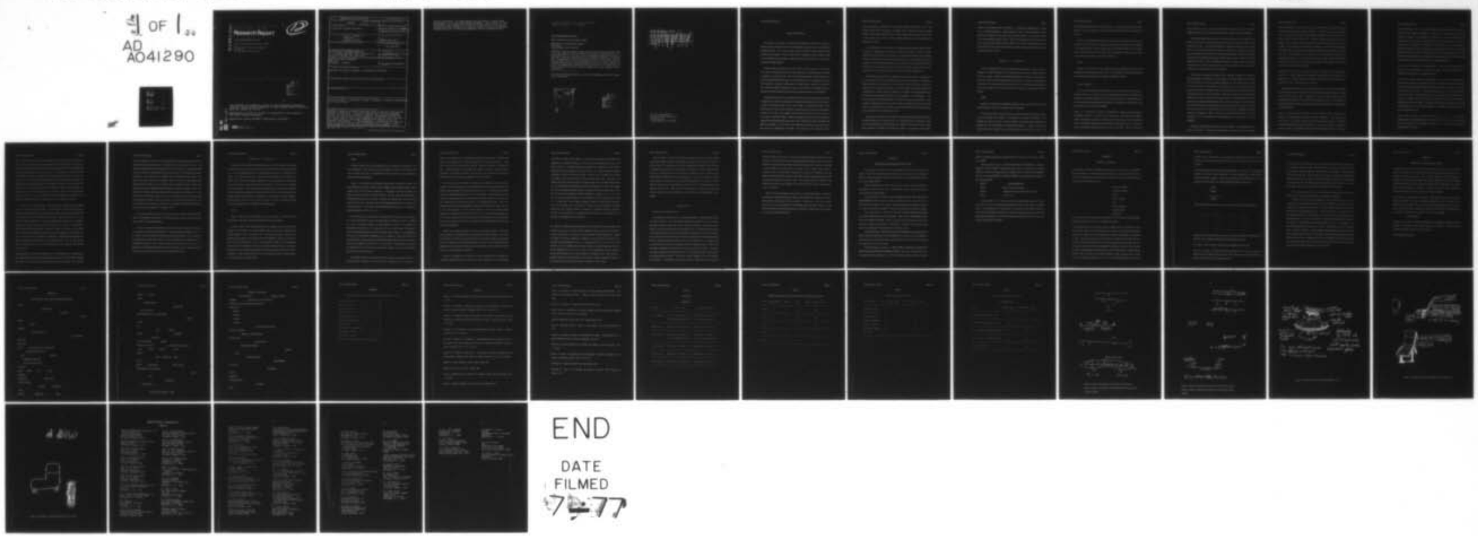
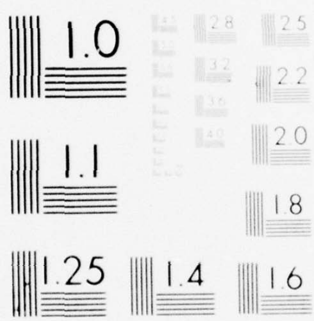
AD-A041 290 IBM THOMAS J WATSON RESEARCH CENTER YORKTOWN HEIGHTS N Y F/G 5/10
AIDS FOR PROBLEM SOLVING.(U)
MAR 77 J C THOMAS, D LYON, L A MILLER N00014-72-C-0419
UNCLASSIFIED RC-6468 NL

1 OF 1
AD
A041290



END
DATE
FILMED
7-77



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

ADA041290

RC 6468 (#27695) 3/3/77 (Rec'd 4/6/77)
Computer Science 33 pages

12

Research Report

AIDS FOR PROBLEM SOLVING*

John C. Thomas, Don Lyon, and Lance A. Miller

IBM Thomas J. Watson Research Laboratory
P. O. Box 218
Yorktown Heights, New York 10598

This research was supported in part by the Engineering Psychology Programs, Office of Naval Research, Contract Number N00014-72-C-0419, Work Unit Number NR-197-020.

IBM Research Division
San Jose · Yorktown · Zurich

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: RC6468
2. GOVT ACCESSION NO.: 14 RC-6468
3. RECIPIENT'S CATALOG NUMBER:
4. TITLE (and Subtitle): 6 Aids for Problem Solving
5. TYPE OF REPORT & PERIOD COVERED: 9 Interim Technical Report
6. PERFORMING ORG. REPORT NUMBER:
7. AUTHOR(s): 10 John C. Thomas, Don Lyon, Lance A. Miller
8. CONTRACT OR GRANT NUMBER(s): 15 N00014-72-C-0419
9. PERFORMING ORGANIZATION NAME AND ADDRESS:
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: NR,-197-020
11. CONTROLLING OFFICE NAME AND ADDRESS: International Business Machines, T. J. Watson Research Center P.O.Box 218, Yorktown Heights, New York 10598
12. REPORT DATE: 3/3/77 11 3 Mar 77
13. NUMBER OF PAGES: 38 12 41p.
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): Office of Naval Research, Code 455, Arlington, Virginia
15. SECURITY CLASS. (of this report):
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report): Approved for public release; distribution unlimited
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report):

349 250

18. SUPPLEMENTARY NOTES
19. KEY WORDS (Continue on reverse side if necessary and identify by block number): problem solving creativity design cognition problem understanding aid human factors
20. ABSTRACT (Continue on reverse side if necessary and identify by block number):

ABSTRACT: Numerous attempts have been made to provide computerized problem solving aids. In most instances such aids are designed without any previous systematic study of the problem solvers who are to use such an aid or any subsequent validation that such aids are really useful. This paper presents the results of two preliminary experiments. In one experiment, a structured aid was not found to be an effective aid to problem solving. However, there were indications of how such an aid might be improved. In a

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

LB

second experiment, an unstructured aid was found to facilitate performance on two creative design problems. The results of this experiment also suggest that creative ideas tend to occur in sequences and that subjects are relatively more likely to terminate suggestions with a creative suggestion than an uncreative one.

RC 6468 (#27695) 3/3/77 (Rec'd 4/6/77)
Computer Science 33 pages

AIDS FOR PROBLEM SOLVING*

John C. Thomas, Don Lyon, and Lance A. Miller

IBM Thomas J. Watson Research Laboratory
P. O. Box 218
Yorktown Heights, New York 10598

ABSTRACT. Numerous attempts have been made to provide computerized problem solving aids. In most instances such aids are designed without any previous systematic study of the problem solvers who are to use such an aid or any subsequent validation that such aids are really useful. This paper presents the results of two preliminary experiments. In one experiment, a structured aid was not found to be an effective aid to problem solving. However, there were indications of how such an aid might be improved. In a second experiment, an unstructured aid was found to facilitate performance on two creative design problems. The results of this experiment also suggest that creative ideas tend to occur in sequences and that subjects are relatively more likely to terminate suggestions with a creative suggestion than an uncreative one.

---

* This work was partially supported by a contract from the Engineering Psychology Programs, Office of Naval Research.

LIMITED DISTRIBUTION NOTICE

This report has been submitted for publication elsewhere and has been issued as a *Research Report* for early dissemination of its contents. As a courtesy to the intended publisher, it should not be widely distributed until after the date of outside publication.

Copies may be requested from:
IBM Thomas J. Watson Research Center
Post Office Box 218
Yorktown Heights, New York 10598

Aids for Problem Solving

The purpose of this paper is to describe some preliminary results of our attempts to examine aids for problem solving. We were particularly interested in ways to help people formulate problems. First, a brief overview is given of the kinds of aids to problem solving that have been proposed. Then the results of two experiments in which college students solved problems with and without a problem solving aid are presented. A short general discussion concludes the paper.

Problem solving is defined here to be the activity by which a person (or other system) tries to achieve a goal when the person (or other system) has no existing (practical) algorithmic procedure for reaching the goal. There have been many attempts to provide computer aids to persons engaged in problem solving. An aid is defined here to be any procedure or material which purports to increase the effectiveness of problem solving. Generally, such aids have been constructed without systematic prior study of the behavior of the problem solvers, or subsequent controlled validation that the proposed problem solving aid is actually helpful.

Though the empirical work on problem solving aids is much more limited than the range of suggested aids, there is one suggested aid to problem solving which has been the subject of a number of experimental studies. This is the technique of 'brainstorming' (Osborn, 1963). The notion here is that a group of people get together and produce many ideas while delaying evaluation of those ideas. This technique, reviewed extensively by Stein (1975), has been used in a variety of real-world settings. However, empirical research provides little unequivocal evidence that such groups produce more ideas or better ideas than the ideas of individuals who make up such groups. In other words, a more efficient use of people's time seems to be to have them work independently. (Bouchard, 1969; Bouchard, 1972a; Bouchard, 1972b;

Bouchard, Barsaloux, and Drauden, 1974; Bouchard, Drauden, and Barsaloux, 1974). This example illustrates that one should not uncritically accept a proposed procedure for aiding problem solving without empirical evidence. Such evidence might indicate the overall effectiveness of such an aid as well as the types of persons, problems, and setting conditions most conducive to its utility.

As a preliminary to a study of behavior in complex real-world problem solving, we have conducted two experimental investigations of simpler problem solving. In the first of these experiments, the effectiveness of an example of a structured aid (defined below) to problem solving was investigated. In the second experiment, the effects of an unstructured aid were investigated. These preliminary experiments were conducted, not only to assess the effects of these aids, but also to determine the kinds of behaviors exhibited in certain problem solving situations, and to develop useful methods of characterizing problem solving behavior.

The problem solving aids for these experiments were chosen based on a consideration of the many suggestions for aids to problem solving that have been proposed. Though these proposed methods vary tremendously, one may usefully classify most of them according to whether they are structured or unstructured. A structured aid is an algorithm or heuristic that essentially limits or directs the person's approach to a problem (at least temporarily).Examples of structured aids include the following --1. use hill-climbing; 2. work backwards; 3. try to solve an easier but related problem first; 4. write down the givens in the problem; 5. chose a subgoal. Though the directions given in these cases are all rather vague, they do direct the person to a particular activity. Useful lists of some of these aids (heuristics, guides for action) are given in Polya, (1957) and Wickelgren (1974).

In contrast to structured aids, other writers have suggested methods designed to increase the idea production rate of a problem solver or to expand the range of considerations. Such aids do not direct the person along particular lines. Indeed, they seem to encourage a broader range of behaviors. Examples of such techniques include: 1. use a matrix of characteristics

relevant to the problem and pick a random cell; 2. imagine that something false is actually true; 3. Think metaphorically; 4. Delay judgement of ideas. Various combinations of these and other techniques have been called lateral thinking (deBono, 1967), synectics (Prince, 1970) and brainstorming (Osborn, 1963). Some of these methods do seem to aid the production of creative ideas (Warren and Davis, 1969). For a review of the experimental evidence on the effects of various kinds of proposed aids to problem solving and creativity the reader is referred to Stein (1974, 1975).

Experiment I ---- Structured Aid

In the first experiment, the use of a structured aid was investigated. This aid, shown in Appendix A, directed the subjects to write down various aspects of the problem statement. We did not attempt to design the best possible structured aid. Rather, our purpose was to explore the effects of an aid that addressed a specific issue-viz., the subject's understanding of the problem. The aid therefore forced the subject to focus his attention successively upon the objects and attributes of the givens and the goal and upon the actions possible within the problem.

Method

Subjects. The subjects were undergraduate subjects at Pace University who were paid for their participation. There were 10 subjects in each of two groups.

Procedure. Each subject was presented with a booklet with general instructions followed by a fixed sequence of six problems. The problems are presented in Appendix B. The problems were chosen to present a range of difficulty and problem types characteristic of problems that have been studied in the psychological laboratory. Subjects in the Control Group were given five minutes for each problem during which time they were told to 'just

think about the problem without really trying to solve it'. Then they were given ten or fifteen minutes to work on a problem, (except for the last problem for which they were allowed 45 minutes).

Subjects in the Experimental Group were given the same problems in the same order except that they spent the first five minutes actively filling out the questionnaire in Appendix A which directed them to consider certain aspects of the problem statement. Prior to beginning the problem solving itself, the subjects in the Experimental Group were given about twenty minutes pre-training on the use of the questionnaire.

Results

Effects of Aid. Of the five 'easy' problems that subjects attempted, the Control Group outperformed the Experimental Group on three. The sixth problem, which required designing an algorithm, proved too difficult. The results are summarized in Table 1.

General observations.

Several of the problems proved too difficult for many of the subjects to solve. However, interesting behavior was produced in the pipe and ping pong ball problem, the hobbits-orcs problem, the card deduction problem and in the bicycle and fly problem. Further discussion of the pipe and ping-pong ball problem will be deferred to a consideration of Experiment II, since the problem was also given in that experiment.

Results of the Hobbits-Orcs problem. The Hobbits-Orcs problem has been studied in considerable detail (See, e.g., Thomas, 1971, 1974; Greeno, 1974; Reed, Ernst, & Banjeri, 1974). The problem as presented in this study differs from previous work in that here the subject was presented the problem in pencil and paper form and asked to solve it. He was not given any intermediate feedback about the correctness of his moves. This fact resulted in a

small proportion of solvers and an interesting contrast between the variety of behaviors exhibited in the current 'open' situation and the previous, computer-controlled, experiments.

Among those subjects who were not given a problem formulation aid, two subjects did not provide for a method of getting the boat back across the river; rather, they simply took the creatures over in twos. Three subjects attempted to complete the problem but were not able to do so. That is, they did not arrive at what they considered to be a solution. One subject had one hobbit and one orc cross the river and then buy a bigger boat. Three subjects thought they had solved the problem but began by moving a hobbit and an orc across the river and bringing the orc back. Without the feedback provided by a computer-control or a watching experimenter these subjects overlooked the fact that the two hobbits on the starting shore would be eaten. Only two subjects solved the problem.

The evidence here suggests that subjects did not completely internalize the constraints of the problem simply by reading them. Further evidence on this point comes from a consideration of the subjects who received the problem formulation aid. These subjects were less likely to violate the constraints of the problem in an obvious way at the cost of being less likely to produce any solution to the problem. Hence, the aid seemed to help in the limited sense that it made subjects more aware of the constraints. Among the ten subjects who used the problem formulation aid, only one simply took the creatures across in pairs without providing for the return trip; that subject explicitly mentioned this as a flaw in his solution. Six of the subjects did not finish the problem. Only three subjects gave erroneous solutions. In those three cases, they gave what would have been solutions if the orcs could 'briefly' outnumber the hobbits when the orc 'dropped off' a hobbit. Subjects in an earlier experiment (Thomas, 1971) also attempted to do this occassionally but were immediately given feedback that it was not permissible.

No subject seemed to misstate the goals, the initial conditions, or the characteristics of the objects in the problem. An interesting though predictable result was that while all ten subjects

listed as a characteristic of the orcs that orcs could eat hobbits if they outnumbered them, only one subject listed the converse property of hobbits --- that they could be eaten if outnumbered. No subject showed any sign of translating the problem into more abstract terms. Also, no-one in either group of subjects drew a complete representation of every state in the problem. This was probably the main reason that the problem proved difficult for subjects attempting to solve it quickly without immediate feedback: they could not accurately anticipate the results of their actions in terms of violating the constraints of the problem-- though they were *aware* of the constraints, and *never* made an error in determining the numbers of orcs and hobbits on the shore *to which* they were moving. (For example, a subject never began by saying, 'Take over one orc and one hobbit, have the hobbit go back and get the other orc and then all three orcs will be on the right side').

Card-deduction problem. The card deduction problem is described by Wason and Johnson-Laird (1972). Table 2 indicates the proportions of subjects giving various answers in our Experimental and Control groups and in the original results reported by Wason and Johnson-Laird (1972, p. 182). (The correct answer is A and 7).

Considering the small sample in the present experiment, the results are fairly comparable to those found by Wason and Johnson-Laird except that our subjects appeared a bit more likely to reach the correct answer. Perhaps this is because for both groups, the subjects thought about the problem for five minutes before attempting to solve it. An examination of the questionnaires filled out by the Experimental group reveals why many of the subjects failed to solve the problem.

Listing the objects. For the first question ---list all the objects that are involved in this problem ---- one person wrote 'four cards, 26 letters, 26 numbers'. These objects are all rather concrete. In particular, the subject did not list propositions as objects. Nor did the person even differentiate vowels from consonants or odd from even numbers. This subject's view of the objects of the problem, as characterized by the comments on the aid, are concrete

and undifferentiated. Four of the subjects simply listed the four cards and the other six subjects included mention of numbers or letters, but no subject treated the relevant *propositions* as objects. The reason that so few adults seem to use formal operations in this problem may not be that they are unable to perform the formal operations, but that their representation of the elements of the problem is so concrete that it does not induce them to apply formal operations. Further evidence relevant to the limitations on people's use of formal operations derives from Wason and Johnson-Laird (1972) who investigated behavior on other problems formally identical to the card problem. Perhaps an important goal for future problem formulation aids would be to induce people to view the problem abstractly.

Actions on objects. In answer to the second question ---- what can you do with the objects-- people said you can turn them over. Again, this is concrete and not terribly helpful. No-one mentioned testing, verification, or disproving as actions.

State the goal. People's answers to the third question --- to state the goal --indicated another possible difficulty with the card-deduction problem. A necessary, but not sufficient condition for solving the problem among this sample of subjects was that they stated the goal in terms of testing *whether* the rule was true. Three subjects stated the goal as *to prove* the rule correct, and all of these subjects missed the problem. These results suggest that even when the goal of a problem is explicitly given in the instructions, some (in this case 3/10) will misread or misinterpret the goal of the problem. An interactive problem solving aid might be able to help avoid this kind of error by forcing the problem solver to elaborate the goal and to state the goal in several different ways.

State the initial conditions. The answers to question four of the aid -- to state the initial conditions-were not revealing except insofar as they provided additional evidence that subjects had a very concrete view of the problem. No subject explicitly mentioned the possibilities for the hidden sides of the cards.

Objects and characteristics. Question five asked the subjects to relist the objects, and for each object to list a characteristic that might be important in solving the problem. Here again, it was obvious that certain subjects would not obtain the correct solution to the problem because they had already formulated the problem incorrectly. As characteristics of the the four cards, some subjects wrote down as actual facts what would be on the other side of the card *if the rule were true.* The characteristics listed by the three subjects who solved the problem were more general than were the characteristics of the subjects who did not solve the problem. For example, one of the subjects who solved the problem gave 'cards' as the objects and 'two sides, one side showing' as the characteristic. In contrast, a subject who did not solve listed the objects as 'A, D, 4, 7' and associated with these listed respectively, 'should have even number', 'should have odd number', 'should have vowel', and 'should have consonant'.

Fly and bicycle. Attempted solutions to the fly and bicycle problem could be classified into one of the categories shown in Table 3. The classification of 'complete insight' indicates a subject who stated that the bicycles would take 1 hour to meet and since the fly flies 100 miles per hour, the fly would fly 100 miles during that hour. 'Inductive insight' refers to a case wherein the subject attempted to use successive approximations but quit after a few approximations and wrote that the journeys of the fly would sum to 100 miles. 'Proportionality' indicates that the subject realized that in each unit of time the fly flew twice as far as each bicycle. 'Successive approximations' indicates that the subject added up a moderate number of terms in an infinite series and rounded off to 100 miles. 'Equal distance' indicates that the subject (erroneously) indicated that the fly would always fly as far as either bicycle. 'Successive approximations' indicates that the subjects tried to use a geometric series but used the wrong series.

An asterisk indicates a wrong or an omitted answer. In this problem, there is a suggestion that the problem solving aid may have encouraged people to perceive too much detail by having them specify so much about the problem and thereby obscured perception of the relations

between problem parts. There was one case among the ten experimental subjects wherein the subject did restate the goal wrongly. This subject said that the goal was to find out '...how many times does the bee go back and forth and for what total distance.' That this subject came up with no answer is not surprising given that the restatement of the goal implied an impossible subgoal. Also of interest in this problem were the representations that subjects used. Nearly every subject had some sort of diagram. There was a feature of these diagrams that predicted perfectly whether or not the subject solved the problem by insight. Exactly those subjects that solved by complete insight had diagrams in which the distance 100 miles was indicated with identical starting and ending points as two segments of 50 miles each. In most cases, this was indicated on a single line. In some cases however, there were two lines, but with coordinated and defined end points to the lines. Apart from that crucial difference, some of the diagrams of those subjects who failed to solve insightfully were quite similar to those of the subjects who solved insightfully. See Figures 1 and 2.

These results seem quite similar to those reported by Paige and Simon (1966) who studied subjects solving algebra word problems. They found suggestive evidence that 'good' problem solvers tended to use integrated diagrams.

Conclusions. The results of Experiment I did not indicate that the particular structured aid studied improved problem solving performance. The aid proved quite valuable however, for the insight it gave into the difficulties that subjects had with the problems. It is also clear that a fair proportion of subjects who attempt to solve such problems have a fundamental misunderstanding concerning the goals, the initial conditions, or the properties of the objects. In addition, the results suggest that workable structured aids might do well to encourage subjects to adopt more abstract representations than they would spontaneously use.

Experiment II --- Unstructured Aid

Perhaps the only real function of problem solving aids is to add variability to the thought productions of the solvers while keeping them focussed on the problem. Unstructured aids do this in a fairly straightforward fashion. Structured aids may function in essentially the same manner. The suggested heuristic may simply redefine the problem by the introduction of another set of constraints and thereby temporarily increase idea production. If this explanation is correct, then a random sequence of words should be as effective an aid to problem solving as anything else. The aid used in the second experiment was constructed in accordance with this hypothesis and consisted of a booklet filled with words. The words presented were actually not chosen randomly but were sampled from a wide number of separate domains of human knowledge. Most of the words were also chosen to be salient. The particular words were chosen independently of the problems used in Experiment II.

Method

Subjects. There were sixteen subjects in each of two groups. Each subject was an undergraduate at The King's College and was paid for his or her participation.

Procedure. Subjects in the Experimental and Control condition were each given the same sequence of four problems. Two of the problems were of a type that is generally called 'insight' problems. One of the problems was a structural design problem and one was a procedural design problem. The problems are shown in Appendix C. Subjects in the Control group were given fifteen minutes to work on each problem. Subjects in the Experimental Group were given five minutes to work on each problem initially; then they were interrupted and asked to look at the problem formulation aid (the first two pages of which are shown in Appendix D). After looking at the aid for five minutes they were asked to continue working on the problem for five additional minutes.

Results

Problem Difficulty. The first two problems proved too difficult for the subjects to solve in the time allowed. No subjects solved the first problem (ten stacks of ten coins each) and only one subject (who was in the Experimental Group) solved the second problem (de-cornered checkerboard covering).

Design a chair. Results for the problem in which subjects were asked to design a chair were analysed in several ways. Figures 3-5 show example responses judged as highly creative, medium creative and low creative respectively. A psychologist other than the authors was asked to rank the 32 answers for overall creativity. (This was done without knowledge of which group the subject was in, of course). The ranks were assigned with 1 as the best overall chair and 32 the worst. The average rank for the Experimental Group was 14.9 and for the Control Group 18.1. This results favors the Experimental Group but is not statistically significant (Rank Sum Test $z = 1$, $p = .16$.)

The third author (who was unaware of the grouping of the subjects) rated the solutions on a scale one through five for each of three dimensions 1) feasibility, 2) novelty 3) complexity. Again, a low number indicates a solution judged to be better. For feasibility, the Experimental Group mean was 2.5 as opposed to 2.9 for the Control Group. With respect to novelty, the Experimental group was rated 2.6 and the Control Group 3.4. The Experimental Group was also rated higher on complexity (2.8, as opposed to 3.8 for the Control.) The overall difference in ratings was 8.06 for the Experimental Group and 10.19 for the Control. This result was significant ($t(30)=3.16$, $p < .01$, two-tailed). The Experimental Group for this problem also wrote on the average, nearly twice as many words as the Control Group (62.8 and 32.6 words, respectively).

An additional analysis was carried out on the basis of the various attributes of chairs. A prototypical chair was defined as one with four legs, a rectangular back, a rectangular seat,

with the various elements in the usual parallel or perpendicular arrangements. The ideas of the subjects were characterized as to their originality along the following dimensions --- shape, place, color, legs, back, arms, covering, materials. These are dimensions of a prototypical chair. A subject's treatment of each of these chair elements was classed as ordinary, different, unspecified, or mentioned as an option. Also, the ideas were scrutinized for the number of additional dimensions. The relevant comparisons are shown in Table 4.

Pipe and ping-pong ball problem. The solutions to the problem of how to get a ping-pong ball out of a pipe also seemed to favor the Experimental Group. Proposed solutions were classified without knowledge of which group the subject was in. The number of total suggestions for the Experimental Group was 53; 44 for the Control. Some suggestions were not considered to be goal-directed (e.g., console yourself by eating the wheaties). There were four such suggestions in the Control Group and one in the Experimental Group. This left 52 goal-directed solutions for the Experimental Group and 40 for the Control Group. One way to classify the suggestions is in terms of their originality. There were 4 unique solutions suggested by the Experimental Group and 3 by the Control. For suggestions appearing three or fewer times among the 32 subjects, there were 26 such suggestions from the Experimental Group and 13 from the Control. Thus, it appeared that the Experimental Group had more nearly unique suggestions.

Another way to classify suggestions is in terms of their judged workability. The Experimental Group gave 29 suggestions that were considered workable as opposed to 11 for the Control Group. In contrast, the Control Group gave 28 suggestions considered non-workable (one was indeterminate). The Experimental Group only gave 23 non-workable suggestions. Appendix E gives the solutions for this problem for Experiments I and II combined for future reference of relative frequency of suggestions.

Patterns of suggestions. The responses to the pipe and ping pong ball problem were combined for Experiments I and II. This allowed a more reliable analysis of the commonality

of patterns of responses across subjects. In order to analyse patterns in the responses, the suggestions were classified according to the type of main action specified (e.g., loop, use air pressure, float, etc.). Each main action was abbreviated by a single letter. Each subject's suggestions were thus summarized as a string of letters. Now, questions could be addressed concerning the regularity of these letter strings. At the first level of analysis, we can simply ask whether certain letters (actions) were more common than others. They were. For example, people were much more likely to suggest looping the ball out than floating the ball out. A second question is whether there are consistent *combinations* of actions. For example, the data were examined to determine whether the suggestions could be strictly ordered. If this were the case, then the suggestions could be arranged in a sequence (s1, s2, ... si...sn) such that any subject who made suggestion si would necessarily have made suggestions s1 through si-1. An examination of these production sequences, however, revealed that the suggestions could not be arranged to form such an order. The data were also examined to determine whether there were consistent *sequences* of suggestions. A transition matrix was constructed with the rows corresponding to the suggested action at position n, and the columns corresponding to the suggested action at position n + 1.

This matrix was collapsed into smaller matrices in which the ideas of looping, wedging, and tweezing were put into one category (obvious suggestions) while the ideas of using floatation, vibration, air pressure, etc. were put into a second category (unusual suggestions). Unusual (as opposed to obvious) suggestions as production n were (relatively) more likely to be followed by unusual suggestions as the n + 1 production ($(\chi^2)(1) = 8.18$, $p < .01$). Unusual responses were also (relatively) more likely to terminate a production sequence than were obvious suggestions ($(\chi^2)(1) = 17.96$, $p < .001$). It is as though subjects were not willing to quit until they thought of at least one idea that they considered creative. Since there are a number of different creative possibilities for the problem, perhaps this tendency of subjects to be satisfied with one unusual solution may have limited their creative output.

World knowledge. A creative idea is generally considered to be one that is both relatively original and workable. Subjects in this problem often failed on the second of these criteria. If taken seriously, 13/52 subjects gave one or more suggestions that indicated serious difficulties in imaging the spatial constraints of the problem. For example, one subject suggested putting the claw of the hammer beneath the ping pong ball (remember, the pipe is .06 inches wider than the ball) and lifting the ball out on the hammer claw. Ten of the 52 subjects also showed a misperception of air pressure and seven showed misjudgement of the rigidity of various materials. (To some extent such judgements are subjective since the actual instantiations of the materials were not used). Such results caution researchers in cognitive psychology and artificial intelligence from over-romanticizing human ability to use world knowledge to solve problems.

General Discussion

Structured and Unstructured Aids

The experiments described above are obviously preliminary. Several interesting results were obtained, however. First, the particular structured aid chosen did not seem to improve performance, though it seemed likely, a priori, that forcing subjects to attend to the objects, attributes, actions, initial state and final state might well do so. An unstructured aid did seem to aid problem solving on two creative design problems. Naturally, it is too early to generalize about structured versus unstructured aids. Perhaps, which type of aid is best depends upon the particular problem or upon the cognitive style of the problem solver. For example, some people may tend to focus too early for optimal solution to a particular problem. In that case it is probably advantageous to give them an aid that will broaden their thinking. Conversely, some people working on more defined problems (e.g., theorem-proving) may spend too much time thinking about irrelevancies. In that case, a directive suggestion like 'work backwards' may be helpful. It is interesting to note though that there is still no hard evidence that the

following hypothesis is not true: To the extent that proposed heuristics and problem solving aids work *in general*, they work only because, through their introduced novelty, they keep the problem solver focussed on the problem longer while activating a greater amount of potentially relevant knowledge. Of course, there are *particular cases* in which a given heuristic is obviously of value. In books written on the subject (e.g., Polya, 1957, Wickelgren, 1974) the author knows full well what the solution to the problem is before offering the heuristic, and for that particular problem, the heuristic is useful. The unresolved question is whether, if one integrates time gained on some problems of a class and time lost on others of the same class, there is a net savings.

While the structured problem solving aid did not facilitate performance, it did furnish interesting data concerning the manner in which certain problems were viewed by the subjects. People tended to represent problems very concretely. In many cases, it was clear that people did not have an accurate representation of the problem before they began to solve it. If this could be determined from formal characteristics of the person's representation, then a potential for a very useful structured aid exists.

Appendix A

PROBLEM QUESTIONNAIRE INSTRUCTIONS

We are going to ask you to fill out a questionnaire before you start solving each problem. We believe this questionnaire may help you to solve the problems. Please think about the problem and questions and give your best answer. We will explain these questions now, using a sample problem.

Suppose someone has just told you about the tic-tac-toe game. We'll use this game -- or problem, given that you want to win! -- as an example to show you what we mean by each of the questions in the questionnaire.

The first question is: LIST ALL OF THE OBJECTS THAT ARE INVOLVED IN THIS PROBLEM. Well, for tic-tac-toe, there is a board, first of all-- that is, three rows of three squares each, forming a 3 by 3 square. Then there are two kinds of markers, circles and x's. These are the objects in the problem. There are also two players who move these objects.

The second question is: WHAT CAN YOU DO TO THESE OBJECTS OR WHAT CAN THESE OBJECTS DO TO EACH OTHER? (LIKE MOVE, TRANSFORM SUBSTITUTE, OR ELIMINATE THEM). Well, in tic-tac-toe, you put both kinds of markers onto the board -- usually by using a pencil to mark them in. At the end of the game you might draw a line through some of the markers (if there are three in a row).

The third question is: WRITE DOWN FOR EACH PROBLEM A PRECISE STATEMENT OF WHAT THE GOAL OF THE PROBLEM IS. The goal is to put the markers on the board in such a way that three markers of the same kind are all in a line, where a line can be a diagonal as well as a row or column.

The fourth question, or request, is: WRITE DOWN A PRECISE STATEMENT OF HOW THINGS ARE WHEN THE PROBLEM BEGINS. Well, in the beginning, there is just the empty board with no markers on it. There are two players, and each player has chosen a

marker. Presumably each player has enough markers for the game, or else can write as many as are needed!

The last question, request, is: WRITE DOWN FOR EVERY OBJECT A CHARACTERISTIC OF THAT OBJECT (EITHER BY ITSELF OR IN A RELATION TO OTHER OBJECTS) THAT YOU THINK MIGHT BE IMPORTANT IN SOLVING THE PROBLEM. There are two headings OBJECT and CHARACTERISTICS and we might fill in as follows for the tic-tac-toe problem:

OBJECT	CHARACTERISTICS
Board	Square, three by three squares
Marker 1	Distinctly different from other kind of marker
Person	wants to win

That's all there is to it. When you answer these questionnaires please be as precise and exact as you can. Put down enough information so that we know what you are talking about -- use abbreviations, etc., if that will help. You will have no more than five minutes to fill out this questionnaire for each problem, so finish the questionnaire before you start really thinking about the problem. If you finish the questionnaire before the five minutes are up, you may start thinking about the problem.

Appendix B

Problems for Experiment I.

1. Assume that a steel pipe is imbedded in the concrete floor of a bare room as shown below. The inside diameter is .06 inches larger than the diameter of the ping pong ball (1.50 inches) which is resting gently at the bottom of the pipe. You are one of a group of six people in the room, along with the following objects:

100 feet of clothesline

A carpenter's hammer

A chisel

A box of wheaties

A file

A wire coat hanger

A monkey wrench

A light bulb

List as many ways as you can think of(in five minutes) to get the ball out of the pipe without damaging the ball, tube, or the floor. (A diagram was included).

2. In this problem there are two kinds of creatures--hobbits and orcs. The hobbits are furry little good guys and the orcs are mean bad guys. On one side of a river there are three hobbits and three orcs. They have a boat on their side that is capable of carrying one or two creatures at a time. . Your goal is to figure out a series of moves or transfers back and forth across the river so that all the hobbits and all the orcs end up safe and sound on the far side of the river. At no point can the orcs on either side outnumber the hobbits (even briefly). Why? Because then the orcs would gang up on the hobbits and eat them. (Equal numbers of hobbits and orcs are OK.) There is no way to cross the piranha filled river except by using the boat. It is OK to have even numbers of hobbits and orcs, or to have the hobbits outnumber the orcs. But

you must never let there be more orcs than hobbits on either side of the river at any time. You must show your step by step sequence of moves back and forth across the river so that we can read it.

3. In the addition shown below each digit was substituted by a code letter. You are supposed to figure out which letter stands for which digit. If a digit is substituted for a letter one place it must be substituted everyplace. No digit can be substituted for more than one letter. If you make the correct substitutions, the resulting addition(in numbers) will be correct.

```
 SEND
+MORE
______
MONEY
```

4. There are four cards in front of you. You can see one side of each card which shows:

```
_________   _________   _________   _________
!       !   !       !   !       !   !       !
!   A   !   !   D   !   !   4   !   !   7   !
!       !   !       !   !       !   !       !
---------   ---------   ---------   ---------
```

You know that each of these cards has a letter on one of its two sides and a number on its other side. Now, consider the following rule concerning these four cards:

If a card has a vowel on one side, then it has a even number on the other side.

Your job is as follows: write down the cards you would have to turn over to figure out whether that rule is TRUE for these four cards. Write down as many cards as you need to test the rule, but don't write down any unnecessary cards.

5. Two bicyclist start 100 miles apart. At a certain time, they begin riding toward each other in a straight line over flat country. When they start, a bee leaves the handlebars of one bicycle and flies toward the other bike. When it reaches the second bike, it turns around and flies back to the first bike. When it reaches the first bike, it instantly turns around and flies back to the second and so on until the two bikes reach each other in the middle. The bee flies a hundred miles an hour. The bikers each go only fifty miles per hour. Question: what is the total distance that the bee has flown when the two bikers meet in the middle?

This is your final problem. It is a fairly difficult one, and requires some time and patience to solve. Please take as much time as you need(up to 45 minutes).

There are 10 three-by-five cards arranged in a line on a table in front of you. There is a single letter of the alphabet on the face of each card. Nothing is on the other side of the cards and no two cards have the same letter. As you look at them on the table, the cards are arranged in the following haphazard order: 'J B Z W M A P R D T'. Your task is to write down an exact procedure for arranging these cards in order form left to right so that they are in alphabetical order. You must be as specific as possible in the commands which you use in this procedure. A command such as 'Find the card with an 'N' on it.' is not sufficient; you must tell specifically how such things are to be done. Your procedure must also be complete, so that a stranger could follow it without knowing what the procedure does and still end up with the cards arranged correctly. Your procedure must be built up from simple actions like looking at what is on a card, comparing that to what is on another card, or moving a card (one at a time) to some other position on the table. Your procedure must work not only for this example, but for any other arrangement of the cards as well.

Appendix C

Problems Given to Subjects in Experiment II

1. Imagine that you have ten stacks of ten coins each. One of these ten stacks is composed entirely of counterfeit coins. Each of the true coins (silver dollars) weighs 100 grams. Each counterfeit coins weighs 101 grams. You also have available a pointer scale capable of weighing to the nearest gram any weight from 1 gram to 10000 grams. This is not a balance scale but more like the fruit scales in groceries. What procedure will determine the counterfeit stack in the fewest number of weighings. (Every time one or more coins is added to or subtracted from the pile on the tray, that counts as another weighing).

2. You are given a checkerboard and 32 dominoes. Each domino covers exactly two adjacent squares on the board. Thus, the 32 dominoes can completely cover the 64 squares of the checkerboard. Now suppose that two squares are cut off at diagonally opposite corners of the board. Is it possible to place 31 dominoes on the board so that all of the 62 remaining squares are covered? If so, show how it can be done. If not, prove it impossible.

(included diagram)

3. Suppose you were asked to produce a better design for an all-purpose chair than any now in existence. Show below the 'best' alternative design you can think of. Take into account consideration of safety, comfort, beauty, and economy.

4. (See Appendix B, problem 1)

Appendix D

First Two Pages of The Unstructured Problem Solving Aid

mirrors

balance beam

fresh apples

playin

sunrise

sunset

computer

tortoise and the hare

miser Scrooge

pancakes &

maple syrup

Pagoda slip and slide on the slippery slush

cranberry juice bitter-sweet

wife freedom

breaking the tape at the

end of a four-minute mile

be creative

gazelle gazette gaze gauze

prejudiced!

Achilles heel Samson's hair

The Fall of Rome

porpoises psychedelic

ancient

wonders Niagra Falls bodily

Wheaties Cheerios

Maypo

burning flame red

salty pretzels

woof, woof, woof

Shrimp tempura served in a Shinto Shrine

massive

caravans

Love

Hate Sadism

Tornado Moonlight

Silk Screen

Alice in Wonderland calculus

Emporer's New Clothes A Stitch in Time Saves Nine

Peru Newton Aristotle Ceasar

Whiskey

Wine Women and Song

Victory

giraffe Filing cabinets Electric Outlets

When Knighthood was In Flower

justice

jokes

motherhood

smell of cloves

diving from the high dive---splash

Through the looking glass

David and Goliath

Cellophane wrappers

Pumpkins

Strike Three! You struck him out!

bumblebees buzzing busy bumbling bombs away

rubber bands

vibrating

vibrating

vibrating

vibrating

reservations will be taken at ...

The Dean of Students

Beethoven's Third Symphony

glowing orange

scent of jasmine

milkweed seeds floating

penguins

bonsai

Westminister Abbey

TOUCHDOWN!

winter winds

handsprings

don't be

prejudiced

fox and the grapes

nosedrops

staples

Appendix E

Solution Frequencies for the Pipe and Ping Pong Ball Problem.

Loop the ball out..........................74

Wedge the ball out.........................18

Use air pressure...........................17

Tweeze the ball out........................16

Float the ball out.........................12

Destroy the boundaries......................6

Use vibration...............................4

Use some sticky substance...................2

Use magnetic force..........................2

Use electric charge.........................2

Miscel. (think, pray, esp, hang yourself)...7

References

Adams, J. *Conceptual Blockbusting*. San Francisco, California: W.H. Freeman and Company, 1974

Bouchard, T. Personality, problem-solving procedure, and performance in small groups, *Journal of Applied Psychology Monograph*, 1969, *53*, (no. 1, part 2),1-29.

Bouchard, T. Training, motivation, and personality as determinants of the effectiveness of the effectiveness of brainstorming groups and individuals, *Journal of Applied Psychology*, 1972a, *56*, 324-331.

Bouchard, T. A comparison of two group brainstorming procedures, *Journal of Applied Psychology*, 1972b, *56*, 418-421.

Bouchard, T., Barsaloux, J. & Drauden, G. Brainstorming procedure, group size, and sex as determinants of the the problem-solving effectiveness of groups and individuals, *Journal of Applied Psychology*, 1974, *59*, (2), 135-138.

Bouchard, T., Drauden, G. & Barsaloux, J. A comparison of individual, subgroup, and total group methods of problem solving, *Journal of Applied Psychology*, 1974, *59*, (2), 226-227.

DeBono, E. *Lateral Thinking*. London: Jonathan Cape, 1967.

Gordon, W. *Synectics*. New York: Harper, 1961.

Greeno, J. Hobbits and orcs: acquisition of a sequential concept, *Cogntive Psychology*, 1974, *6*, 270-292.

Osborn, A. *Applied imagination*. (3rd ed.) New York: Scribner's, 1963.

Paige, J. and Simon, H., Cognitive Processes in Solving Algebra Word Problems. In B. Kleinmutz, (Ed.), *Problem Solving --- Research, Method, and Theory* New York: Wiley, 1966.

Prince, G. *The Practice of Creativity*. New York: Harper, 1970.

Reed, S., Ernst, G., and Banjeri, R. The role of analogy in transfer between similar problem states. *Cognitive Psychology*, 1974, *6*, 436-450.

Stein, M. *Stimulating Creativity*. New York: Academic Press, 1974

Stein, M. *Stimulating Creativity, Volume 2, Group Methods*. New York: Academic Press, 1975.

Thomas, J. An analysis of behavior in the hobbits-orcs problem. Technical Report No. 31, Human Performance Center, University of Michigan, Aug., 1971.

Thomas, J. An analysis of behavior in the hobbits-orcs problem. *Cognitive Psychology*, 1974, *6*, 257-269.

Warren, T. & Davis, G. Techniques for creative thinking: an empirical comparison of three methods. *Psychological Reports*, 1969, *25*, 207-214.

Wertheimer, M. *Productive thinking*. New York: Harper, 1945

Wickelgren, W. *How to solve problems*. San Francisco, California: W.H. Freeman and Company, 1974

Table 1

Solution Data

Experiment 1

Problem	Control Group	Experimental Group
Pipe Problem	Ave. Total Suggestions--3.5	Ave. Total Suggestions--3.5
	Ave. Workable Suggest.--1.9	Ave. Workable Suggest.--1.9
Hobbits-Orcs	Proportion of solvers -- .2	Proportion of solvers -- 0
Crypt-arith	Proportion of solvers -- 0	Proportion of solvers -- 0
	Ave. correct equations--1.5	Ave. correct equations--2.4
Card deduction	Proportion of solvers -- .4	Proportion of solvers -- .3
Bicycle & Fly	Proportion of solvers -- .8	Proportion of solvers -- .4
Algorithm Spec	Proportion of solvers -- 0	Proportion of solvers -- 0

Table 2.

Proportions of Subjects Giving Various Answers to Card Deduction Problem

Answer	Experimental	Control	Total	Wason & Johnson-Laird
A and 4	.3	.4	.35	.46
A and 7	.3	.4	.35	.04
A alone	.1	.1	.10	.33
A,4,&7	0.0	0.0	0.0	.07
Other	.3	.1	.2	.10

Table 3

Types of Attempted Solutions

Solution Type	No. in Exper. Group	No. in Control Group
Complete Insight	1	6
Inductive Insight	0	1
Proportionality	1	1
Successive Approx.	2	0
*Equal Distance	1	0
*Successive Approx.	2	0
*No Answer	3	2

Table 4

'Design a better Chair' Solutions

Frequency Data

Feature	Control Group	Experimental Group
Usual Dimension; Usual Value	36	15
Usual Dimension; Unusual Value	39	61
Usual Dimension; Unspecified Value	27	28
Usual Dimension; Optional Value	18	28
Unusual Dimension	27	33

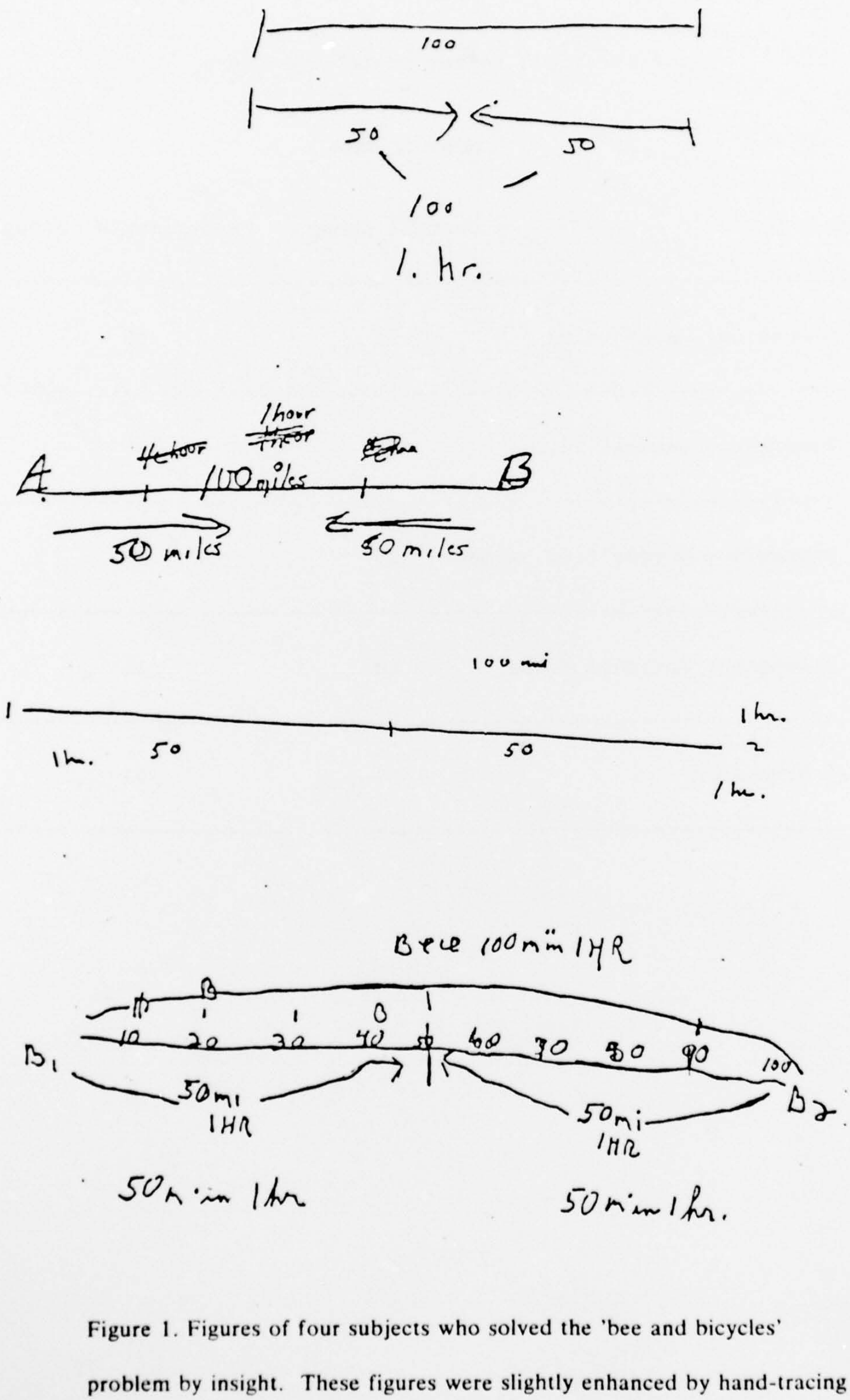


Figure 1. Figures of four subjects who solved the 'bee and bicycles' problem by insight. These figures were slightly enhanced by hand-tracing to improve legibility.

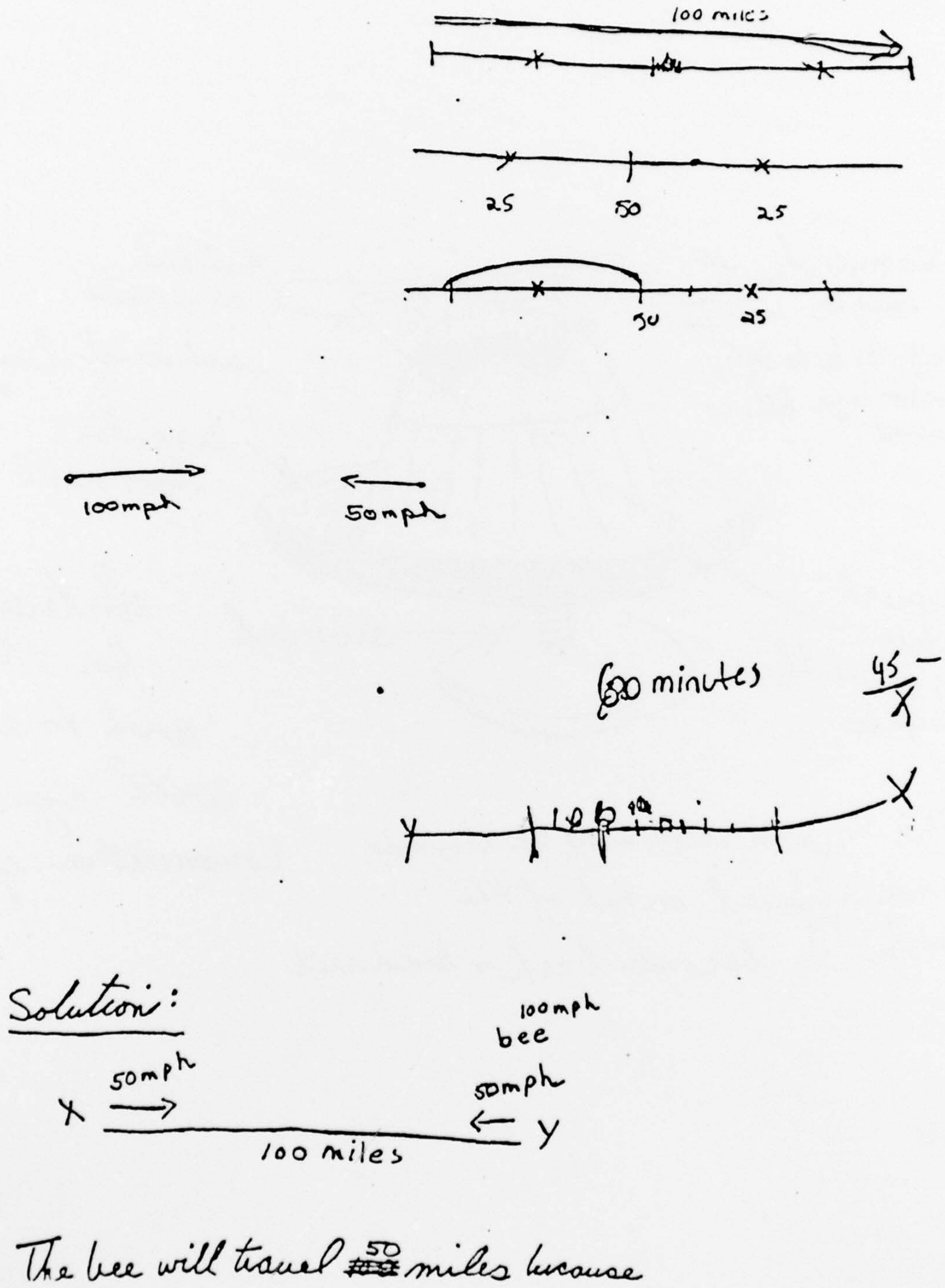


Figure 2. Figures of four subjects who did not solve the 'bee and bicycles' problem by insight. Figures slightly enhanced by hand-tracing to improve legibility.

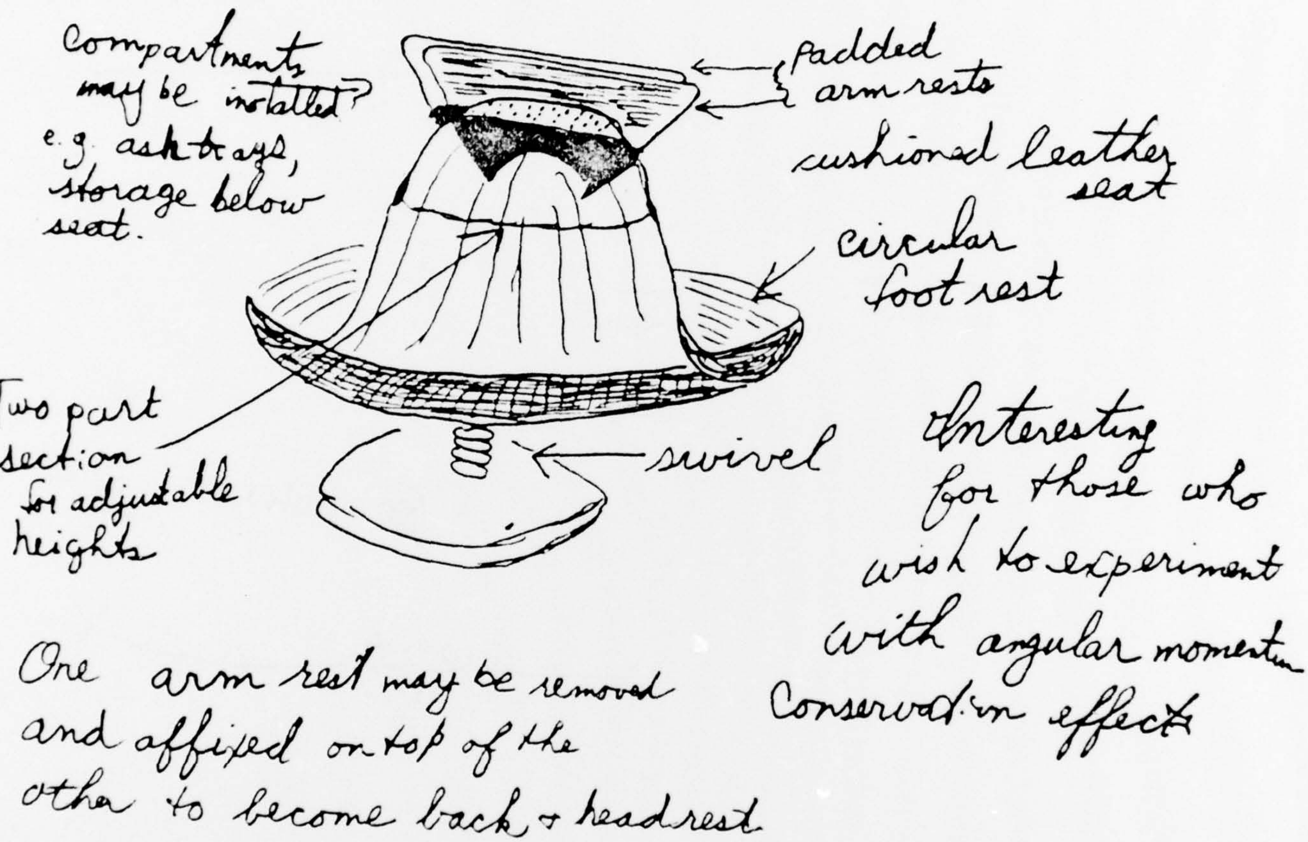


Figure 3. An example of a chair design judged highly creative.

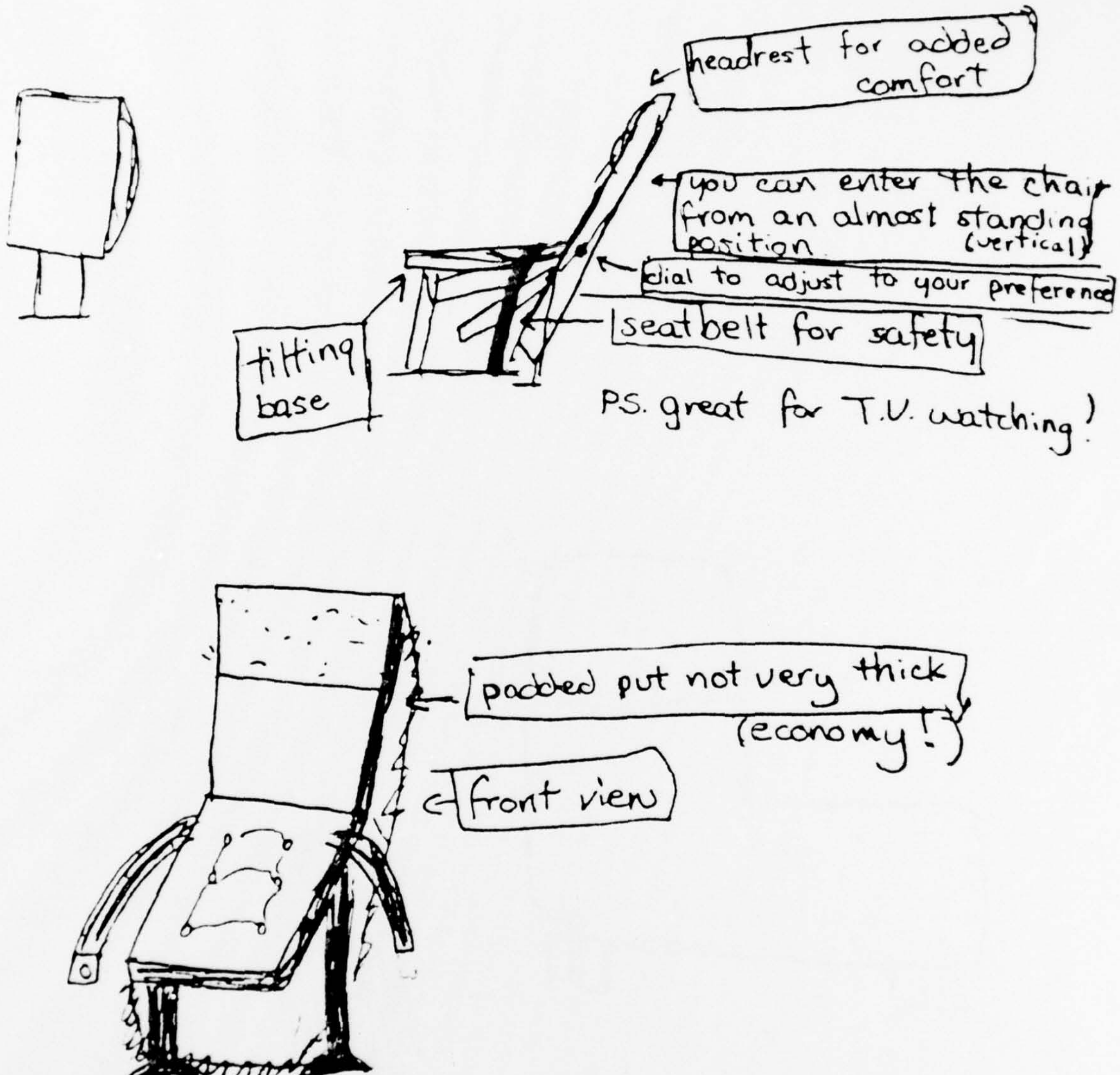


Figure 4. An example of a chair design judged to be medium creative.

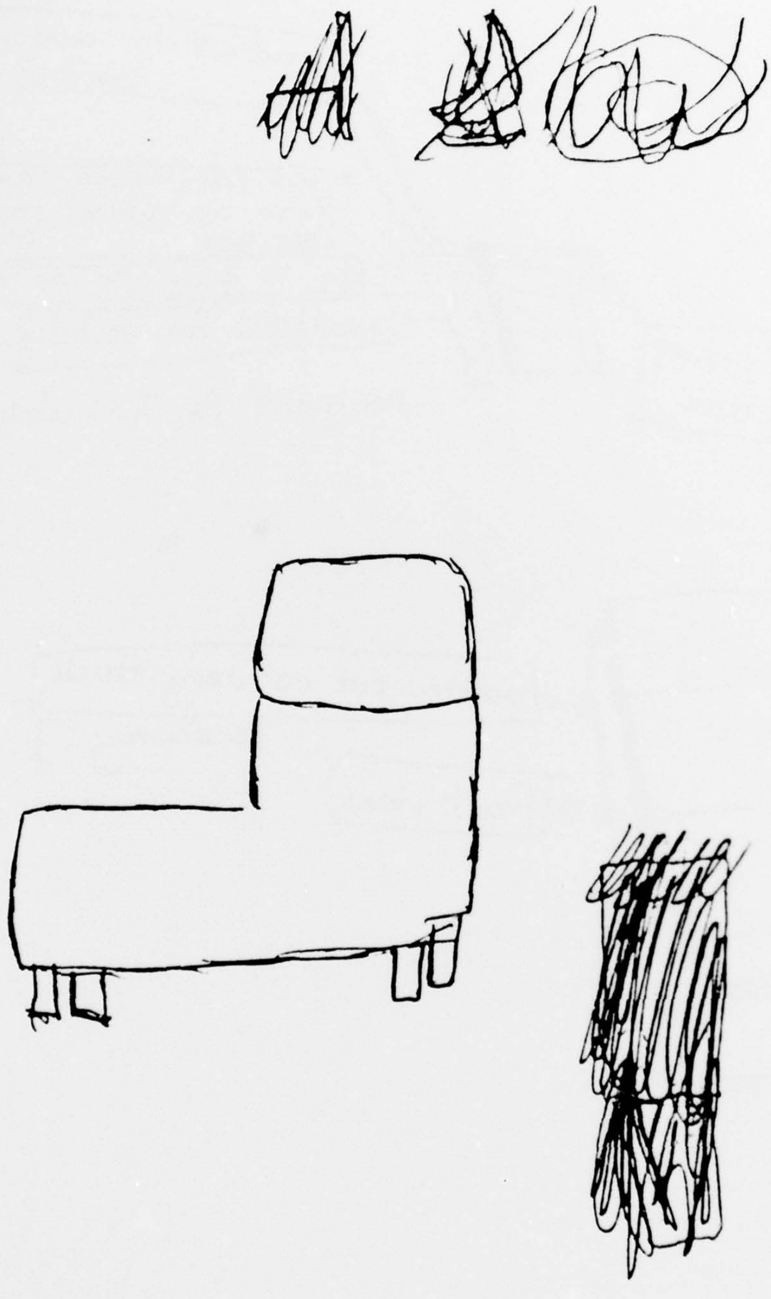


Figure 5. An example of a chair design judged to be low creative.

TECHNICAL REPORTS DISTRIBUTION LIST

CODE 455

Director, Engineering Psychology (5 cys)
Programs, Code 455
Office of Naval Research
800 North Quincy Street
Arlington, Virginia 22217

Defense Documentation Center (12 cys)
Cameron Station
Alexandria, Virginia 22314

Director, ONR Branch Office
ATTN: Dr. J. Lester
495 Summer Street
Boston, Massachusetts 02210

Director, ONR Branch Office
ATTN: Dr. M. Bertin
536 S. Clark Street
Chicago, Illinois 60605

Director, ONR Branch Office
ATTN: Dr. E. Gloye
1030 East Green Street
Pasadena, California 91106

Director, ONR Branch Office
ATTN: Mr. R. Lawson
1030 East Green Street
Pasadena, California 91106

Dir., Naval Research Laboratory (6 cys)
Technical Information Division
Code 2027
Washington, D. C. 20375

Dir., Naval Research Laboratory (6 cys)
ATTN: Library, Code 2029 (ONRL)
Washington, D. C. 20375

Mr. John Hill
Naval Research Laboratory
Code 5634
Washington, D. C. 20375

Office of Naval Research
Information Systems Program, Code 437
800 North Quincy Street
Arlington, Virginia 22217

Office of Naval Research
Operations Research Program, Code 434
800 North Quincy Street
Arlington, Virginia 22217

Office of Naval Research
Naval Analysis Programs, Code 431
800 North Quincy Street
Arlington, Virginia 22217

Office of Naval Research
ATTN: Dr. K. T. Wallenius, Code 436
800 North Quincy Street
Arlington, Virginia 22217

Office of the Chief of Naval
Operations, Op-987E
Department of the Navy
Washington, D. C. 20350

CDR H. J. Connery
Office of the Chief of Naval Operations,
Op-987M4
Department of the Navy
Washington, D. C. 20350

Dr. A. L. Slafkosky
Scientific Advisor
Commandant of the Marine Corps
Code AX
Washington, D. C. 20380

Dr. Heber G. Moore
Hqs. Naval Material Command
Code 0331
Department of the Navy
Washington, D. C 20360

Mr. Arnold Rubinstein
Naval Material Command, NAVMAT 03424
Department of the Navy
Washington, D. C. 20360

Commander, Naval Electronics
Systems Command
Command and Control Div., Code 530
Washington, D. C. 20360

Naval Electronics Systems Command
Human Factors Engineering Branch
Code 4701
Washington, D. C. 20360

Bureau of Medicine and Surgery
Human Effectiveness Branch, Code 713
Department of the Navy
Washington, D. C. 20372

CDR Robert Wherry
Human Factors Engineering Branch
Crew Systems Department
Naval Air Development Center
Johnsville
Warminster, Pennsylvania 18974

LCDR Robert Kennedy
Human Factors Engineering Br., Code 5342
U.S. Naval Missile Center
Point Mugu, California 93042

Lt. Col., Henry L. Taylor, USAF
OAD*E&LS) ODDR&E
Pentagon, Rm. 3D129
Washington, D. C. 20301

Mr. Richard Coburn
Head, Human Factors Division
Naval Electronics Laboratory Center
San Diego, California 92152

Dean of Research Administration
Naval Postgraduate School
Monterey, California 93940

Navy Personnel Research and
Development Center (Code 10) (5 cys)
San Diego, California 92152

Mr. James L. Long
Weapons Systems Research (N-332)
Naval Education and Training Command
Naval Air Station
Pensacola, Florida 32408

Human Factors Dept., Code N215
Naval Training Equipment Center
Orlando, Florida 32813

Dr. George Moeller
Head, Human Factors Engineering Branch
Submarine Medical Research Laboratory
Naval Submarine Base
Groton, Connecticut 06340

Lt. Col. Austin W. Kibler
Director, Human Resources Office
Advanced Research Projects Agency
1400 Wilson Blvd.
Arlington, Virginia 22209

U.S. Air Force Office of Scientific
Research
Life Sciences Directorate, NL
1400 Wilson Blvd.
Arlington, Virginia 22209

Dr. J. M. Cristensen
Chief, Human Engineering Division
Aerospace Medical Research Laboratory
Wright-Patterson AFB, OH 45433

Dr. J. E. Uhlaner
Dir., U.S. Army Research Institute
for the Social & Behavioral Sciences
1300 Wilson Blvd.
Arlington, Virginia 22209

Chief of Research and Development
Human Factors Branch
Behavioral Science Division
Department of the Army
ATTN: Mr. J. Barber
Washington, D. C. 20310

Dr. Joseph Zeidner
Dir., Organization and Systems
Research Laboratory
U.S. Army Research Institute for
the Behavioral & Social Sciences
1300 Wilson Blvd.
Arlington, Virginia 22209

Dr. Stanley Deutsch
Chief, Man-Systems Integration
OART, Hqs., NASA
600 Independence Avenue
Washington, D. C. 20546

Dr. Jesse Orlansky
Institute for Defense Analyses
400 Army-Navy Drive
Arlington, Virginia 22202

Dr. Edgar M. Johnson
Organizations & Systems Research Lab.
U.S. Army Research Institute for the
Behavioral and Social Sciences
1300 Wilson Blvd.
Arlington, Virginia 22209

Dr. James Parker
BioTechnology, Inc.
3027 Rosemary Lane
Falls Church, Virginia 22042

Dr. Edwin A. Fleishman
Foxhall Square
3301 New Mexico Avenue, N.W.
Washington, D. C. 20016

American Institutes for Research Library
135 N. Bellefield Avenue
Pittsburgh, Pennsylvania 15213

Psychological Abstracts
American Psychological Association
1200 17th Street, N.W.
Washington, D. C. 20036

Dr. A. I. Siegal
Applied Psychological Services
404 E. Lancaster Street
Wayne, Pennsylvania 19087

Dr. Joseph Wulfeck
Dunlap and Associates, Inc.
115 South Oak Street
Inglewood, California 90301

Dr. Robert R. Mackie
Human Factors Research, Inc.
Santa Barbara Research Park
6780 Cortona Drive
Goleta, California 93017

Mr. Wes Woodson
Man Factors, Inc.
4433 Convoy Street, Suite D
San Diego, California 92111

Dr. C. H. Baker
Director, Human Factors Wing
Defense & Civil Institute of
Environmental Medicine
P. O. Box 2000
Downsville, Toronto, Ontario
Canada

Journal Supplement Abstract Service
American Psychological Association
1200 17th Street, N.W.
Washington, D. C. 20036

Dr. Bruce M. Ross
Department of Psychology
Catholic University
Washington, D. C. 20017

Mr. Harry Chipman
WR Systems, Inc.
2531 S. Jefferson Davis Highway
Arlington, Virginia 22202

Dr. David Meister
U.S. Army Research Institute
1300 Wilson Blvd.
Arlington, Virginia 22209

Mr. George Graine
Naval Ship Systems Command
(SHIPS 047C12)
Department of the Navy
Washington, D. C. 20362

Lt. Col. John F. Ahlborn
Headquarters, AFSC-DLSE
Andrews AFB
Washington, D. C. 20334

Dr. H. H. Wolff
Technical Director (Code N-2)
Naval Training Equipment Center
Orlando, Florida 32813

Dr. Donald A. Topmiller
Chief, Systems Effect. Branch
Human Engineering Division, USAF
Wright Patterson AFB, Ohio 45433

Col. Robert O. Viterna
DA/OCRD
Headquarters, Dept. of the Army
DARD-ARS-B
Washington, C. C. 20310

Dr. Anthony Debons
IDIS
University of Pittsburgh
135 N. Bellefield Avenue
Pittsburgh, Pennsylvania 15260

Dr. Alfred F. Smode
Training Analysis & Evaluation Group
Code N-OOT
Orlando, Florida 32813